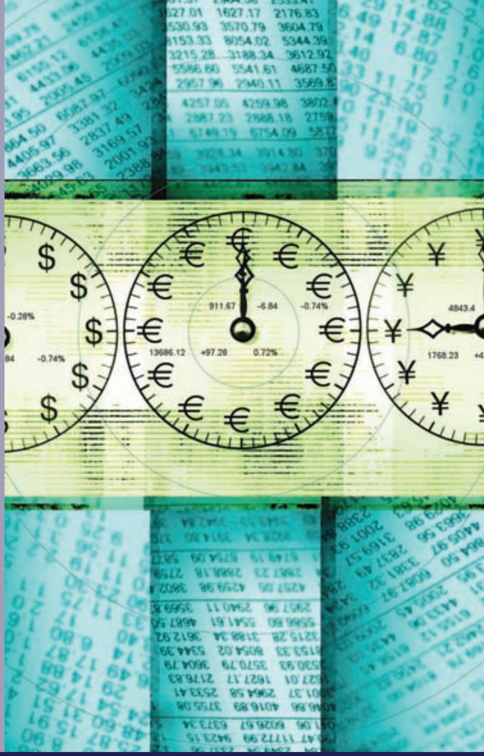
WEB EXTENSION 14A



The Abandonment Real Option

This Extension illustrates the valuation of abandonment options.

THE ABANDONMENT OPTION: AN ILLUSTRATION

Synapse Systems produces a variety of switching devices for computer networks at large corporations. It is considering a proposal to develop and produce a wireless network targeted at homes and small businesses. The required manufacturing facility will cost $26 million. Synapse can accurately predict the manufacturing costs, but the sales price is uncertain. There is a 25% probability that demand will be strong and Synapse can charge a high price; see Table 14A-1 for detailed projections of operating cash flows over the 4-year life of the project. There is a 50% chance of moderate demand and average prices, and a 25% chance of weak demand and low prices. The cost of capital for this project is 12%.

Synapse can sell the equipment used in the manufacturing process for $14 million after taxes at Year 1 if customer acceptance is low. In other words, Synapse can abandon the project at Year 1 and avoid the negative cash flows in subsequent years.

This abandonment option resembles a put option on stock. It gives Synapse the opportunity to sell the project at a fixed price of $14 million at Year 1 if the cash flows beyond Year 1 are worth less than $14 million. If the cash flows beyond Year 1 are worth more than $14 million, Synapse will let the put option expire and keep the project.

TABLE 14A-1 Expected Operating Cash Flows for Project at Synapse Systems (Millions of Dollars)

		Operating Cash Flow			
Demand	Probability	Year 1	Year 2	Year 3	Year 4
High	25%	\$18.00	\$23.00	\$28.00	\$33.00
Average	50	7.00	8.00	9.00	10.00
Low	25	−8.00	−9.00	−1.00	−12.00
Expected operating cash flow =		\$ 6.00	\$ 7.50	\$ 9.00	\$10.25

Approach 1. DCF Analysis Ignoring the Abandonment Option

Using the expected cash flows from Table 14A-1 and ignoring the abandonment option, the traditional NPV is −\$1.74 million:

$$\text{NPV} = -\$26 + \frac{\$6.00}{(1 + 0.12)^1} + \frac{\$7.50}{(1 + 0.12)^2} + \frac{\$9.00}{(1 + 0.12)^3} + \frac{\$10.25}{(1 + 0.12)^4} = -\$1.74.$$

Based only on this DCF analysis, Synapse should reject the project.

Approach 2. DCF Analysis with a Qualitative Consideration of the Abandonment Option

The DCF analysis ignores the potentially valuable abandonment option. Qualitatively, we would expect the abandonment option to be valuable because the project is quite risky, and risk increases the value of an option. The option has one year until it expires, which is relatively long for an option. Again, this suggests that the option might be valuable.

Approach 3. Decision Tree Analysis of the Abandonment Option

Part 1 of Figure 14A-1 shows a scenario analysis for this project. There is a 25% chance that customers will accept a high price for the product, with the cash flows shown in the top line. There is a 50% chance that Synapse can charge a moderately high price, and the cash flows of this scenario are in the middle row. However, if customers are reluctant to buy this product, Synapse will have to cut prices, resulting in the negative cash flows in the bottom row. The sum in the last column in Part 1 shows the expected NPV of −\$1.74 million, which is the same as the traditional DCF analysis.

Part 2 of Figure 14A-1 shows a decision tree analysis in which Synapse abandons the project in the low-price scenario. In particular, if Synapse has the −\$8 million operating cash flow at Year 1 and the prospect of even bigger losses in subsequent years, it will abandon the project and sell the equipment for \$14 million. Note that Synapse will not abandon the project in the average-demand scenario, even though it has a negative expected NPV in Part 1. This is because by the time the average-demand scenario is revealed, the original investment of \$26 million has already been made; it is a sunk cost, as described in Chapter 14. Only the future cash

FIGURE 14A-1 Scenario Analysis and Decision Tree Analysis for the Synapse Project (Millions of Dollars)

PART 1. SCENARIO ANALYSIS OF THE PROJECT (IGNORING OPTION TO ABANDON)

Now: Year 0	Scenario	Branch probability	Year 1	Year 2	Year 3	Year 4	NPV for This Scenario[a]	Probability	Probability × NPV
−$26	High	0.25	$18	$23	$28	$33	$49.31	0.25	$12.33
	Average	0.50	$7	$8	$9	$10	−$0.61	0.50	−$0.31
	Low	0.25	–$8	–$9	–$10	–$12	−$55.06	0.25	−$13.77
								1.00	

Year 1 through Year 4 are the FUTURE CASH FLOWS.

Expected value of NPVs = −$1.74

Standard deviation[b] = $36.92

Coefficient of variation[c] = −21.17

PART 2. DECISION TREE ANALYSIS OF THE ABANDONMENT OPTION

Now: Year 0	Scenario	Branch probability	Year 1	Year 2[d]	Year 3	Year 4	NPV of This Scenario[d]	Probability	Probability × NPV
−$26	High	0.25	$18	$23	$26	$33	$49.31	0.25	$12.33
	Average	0.50	$7	$8	$9	$10	−$0.61	0.50	−$0.31
	Low	0.25	$6[e]	$0[f]	$0	$0	−$19.94	0.25	−$4.96
								1.00	

Year 1 through Year 4 are the FUTURE CASH FLOWS.

Expected value of NPVs = $7.04

Standard deviation[b] = $25.65

Coefficient of variation[c] = 3.64

Notes:
[a]The operating cash flows are discounted by the WACC of 12%.
[b]The standard deviation is calculated as in Chapter 2.
[c]The coefficient of variation is the standard deviation divided by the expected value.
[d]The operating cash flows in Year 1 through Year 4, which do not include the $14 million after-tax salvage value, are discounted at the WACC of 12%. The $14 million salvage value in the low-demand scenario at Year 1 is discounted at the risk-free rate of 6%.
[e]The cash flow at Year 1 for the low-demand scenario is equal to the –$8 million operating cash flow plus the after-tax salvage value of $14 million, since Synapse will abandon the project in this scenario.
[f]The cash flows at Year 2 through Year 4 for the low-demand scenario are zero, because Synapse abandons the project immediately after the –$8 million operating loss at Year 1.

TABLE 14A-2 Sensitivity Analysis of the Synapse Decision Tree Analysis in Figure 14A-1 (Millions of Dollars)

Cost of Capital Used to Discount the Year 1 through Year 4 Operating Cash Flows (These do not include the $14 million after-tax salvage value at Year 1.)	Cost of Capital Used to Discount the $14 Million After-Tax Salvage Value in the Low-Demand Scenario of Year 1						
	3.0%	4.0%	5.0%	6.0%	7.0%	8.0%	9.0%
8.0%	$10.18	$10.15	$10.12	$10.08	$10.05	$10.02	$9.99
9.0	9.38	9.34	9.31	9.28	9.25	9.22	9.19
10.0	8.60	8.57	8.54	8.50	8.47	8.44	8.41
11.0	7.85	7.82	7.79	7.76	7.73	7.70	7.67
12.0	7.13	7.10	7.07	7.04	7.01	6.98	6.95
13.0	6.44	6.41	6.38	6.34	6.31	6.28	6.25
14.0	5.77	5.74	5.71	5.67	5.64	5.61	5.58
15.0	5.13	5.09	5.06	5.03	5.00	4.97	4.94
16.0	4.50	4.47	4.44	4.41	4.37	4.34	4.31
17.0	3.90	3.87	3.84	3.80	3.77	3.74	3.71
18.0	3.32	3.29	3.25	3.22	3.19	3.16	3.13

flows at the time the decision to abandon the project are relevant to the abandonment decision, and their present value is positive in the average-demand scenario. Therefore, Synapse will abandon the project only in the low-demand scenario.

All operating cash flows, which do not include the salvage value in the low-demand scenario of Year 1, are discounted at the WACC of 12%. The salvage value is known with a high degree of certainty, so it is discounted at the risk-free rate of 6%. As shown in Part 2 of Figure 14A-1, the expected NPV is $7.04 million, indicating that the abandonment option is quite valuable. In fact, the option to abandon is so valuable that Synapse should accept the project.

The option itself alters the risk of the project, which means that 12% probably is no longer the appropriate cost of capital. In addition, the estimated $14 million salvage value is relatively certain, but there is a slight chance that it might be either higher or lower. Table 14A-2 presents the results of a sensitivity analysis in which the cost of capital for the operating cash flows varies from 8% to 18%. The sensitivity analysis also allows the rate used to discount the salvage value to vary from 3% to 9%. The NPV is positive for all reasonable combinations of discount rates.

Approach 4. Valuing the Abandonment Option with a Financial Option

The fourth procedure for valuing a real option valuation is to use a standard model for an existing financial option. As we noted earlier, Synapse's abandonment option is similar to a put option on a stock. We can use the Black-Scholes model for the value of a call option, V_{Call}, to determine the value of a put option, V_{Put}:[1]

$$V_{Put} = V_{Call} - P + Xe^{-r_{RF}t} \qquad \textbf{(14A-1)}$$

[1]Equation 14A-1 is derived from the "put-call parity" relationship. Put-call parity means that a portfolio with a put option and a share of the stock has the same payoff at the option's date of expiration as a portfolio with a call option and cash equal to the present value of the strike price:

$$V_{Put} + P = V_{Call} + Xe^{-r_{RF}t}$$

Before we can apply the put formula to determine the value of Synapse's project with an embedded abandonment option, we must break the original project into two separate projects plus an option to abandon the second project. Part 1 of Figure 14A-2 shows Project A, which is a 1-year project that includes the initial cost and first-year operating cash flows of Synapse's project. Part 2 shows Project B,

FIGURE 14A-2 Breaking Synapse's Project into Two Separate Projects of the Investment Timing Option (Millions of Dollars)

PART 1. DCF ANALYSIS OF PROJECT A THAT LASTS ONE YEAR

Now: Year 0	Scenario		Year 1 (Future Cash Flows)	NPV of This Scenario[a]	Probability	Probability × NPV
–$26	High	0.25	$18	–$9.93	0.25	–$2.48
	Average	0.50	$7	–$19.75	0.50	–$9.88
	Low	0.25	–$8	–$33.14	0.25	–$8.29
					1.00	

Expected value of NPVs = –$20.64

Standard deviation[b] = $8.26

Coefficient of variation[c] = (0.40)

PART 2. DCF ANALYSIS OF PROJECT B THAT STARTS IN YEAR 2 IF PROJECT A IS ALREADY IN PLACE

Now: Year 0	Scenario		Year 1	Year 2	Year 3	Year 4	NPV of This Scenario[a]	Probability	Probability × NPV
	High	0.25		$23	$28	$33	$59.24	0.25	$14.81
	Average	0.50		$8	$9	$10	$19.14	0.50	$9.57
	Low	0.25		–$9	–$10	–$12	–$21.92	0.25	–$5.48
								1.00	

Expected value of NPVs = $18.90

Standard deviation[b] = $28.69

Coefficient of variation[c] = 1.52

Notes:

[a]The WACC is 12%. All cash flows in this scenario are discounted back to Year 0.

[b]The standard deviation is calculated as in Chapter 2.

[c]The coefficient of variation is the standard deviation divided by the expected value.

which begins in Year 2, the year after Project A ends. Project B has no cash flows at Year 0 or Year 1, but has the networking project's operating cash flows in the subsequent years. Note that combining Projects A and B gives the same cash flows as Synapse's networking project. Project A has an NPV of −\$20.64 million (shown in the last column in Part 1) and Project B has an NPV of \$18.90 million. The combination of the two projects has an NPV of −\$20.64 + \$18.90 = −\$1.74 million, the same NPV shown for Synapse's networking project. But Synapse also has an option to abandon Project B, which gives Synapse the right to sell Project B for \$14 million. In other words, Synapse can invest in Project A by paying the initial cost of \$26 million, which also gives Synapse the ownership of Project B. But in addition to owning Projects A and B, Synapse also has the right to "sell" Project B for \$14 million.

We can use Equation 14A-1 to determine the value of Synapse's abandonment option. Note that we need the same five factors to price a put option using the Black-Scholes model as we do to price a call option: risk-free rate, time until the option expires, strike price, current price of the underlying asset, and variance of the underlying asset's rate of return. The rate on a 52-week Treasury bill is 6%, and this provides a good estimate of the risk-free rate. The time until the growth option expires is 1 year. Synapse can sell the equipment for \$14 million, which is the exercise price.

The underlying asset in this application of the option pricing model is Project B, since we have the option to abandon it. Project B's "current price" is the present value of its future cash flows. As the last column in Part 2 of Figure 14A-2 shows, this is \$18.90 million.

Figure 14A-3 shows the estimates for the variance of Project B's rate of return using the two methods described in Chapter 14. Note in Part 2 that Project B has a current value of \$18.90 million at Year 0, but by Year 1 it could be worth as much as \$66.35 million or as little as −\$24.55 million. Given this wide range of outcomes, we would expect the variance of the rate of return to be very large. The direct method, shown in Part 2, produces an estimate of 289.2% for the variance of return.

Part 1 of Figure 14A-3 shows a coefficient of variation of 1.518, reflecting the range of potential outcomes. As in the chapter's examples, we can use the indirect method in Part 3 to convert the coefficient of variation at the time the option expires into an estimate of the variance of the project's rate of return, σ^2:

$$\sigma^2 = \frac{\ln(CV^2 + 1)}{t} \tag{14A-2}$$

Applying Synapse's data gives

$$\sigma^2 = \frac{\ln(1.518^2 + 1)}{1} = 1.195 = 119.5\%$$

Both the direct and indirect methods indicate that the project is quite risky, but there is a fairly large difference in their estimates of variance: 289.2% versus 119.5%. This is because the indirect method implicitly assumes that the lowest possible outcome is zero, while the direct method has no such restriction. We decided to use an estimated variance of 175%, which is between the estimates given by the two methods.

FIGURE 14A-3 Estimating the Input for Stock Return Variance in the Abandonment Option Analysis (Millions of Dollars)

PART 1. FIND THE VALUE AND RISK OF FUTURE CASH FLOWS AT THE TIME THE OPTION EXPIRES

Now: Year 0	Scenario	Year 1	Year 2	Year 3	Year 4	PV in Year 1 for This Scenario[a]	Probability	Probability × $PV_{Year\ 1}$
	High	0.25	$23	$28	$33	$66.35	0.25	$16.59
	Average	0.50	$8	$9	$10	$21.44	0.50	$10.72
	Low	0.25	−$9	−$10	−$12	−$24.55	0.25	−$6.14
							1.00	

Expected value of $PV_{Year\ 1}$ = $21.17

Standard deviation of $PV_{Year\ 1}$[b] = $32.14

Coefficient of variation of $PV_{Year\ 1}$[c] = 1.518

PART 2. DIRECT METHOD: USE THE SCENARIOS TO DIRECTLY ESTIMATE THE VARIANCE OF THE PROJECT' S RETURN

$Price_{Year\ 1}$[d]	Scenario	Probability	$PV_{Year\ 1}$[e]	$Return_{Year\ 1}$[f]	Probability	Probability × $Return_{Year\ 1}$
$18.90	High	0.25	$66.35	251.1%	0.25	62.8%
	Average	0.50	$21.44	13.4%	0.50	6.7%
	Low	0.25	−$24.55	−229.9%	0.25	−57.5%
					1.00	

Expected return = 12.0%

Standard deviation of return[b] = 170.0%

Variance of return[g] = 289.2%

PART 3. INDIRECT METHOD: USE THE SCENARIOS TO INDIRECTLY ESTIMATE THE VARIANCE OF THE PROJECT'S RETURN

Expected "price" at the time the option expires[h] =	$21.17
Standard deviation of expected "price" at the time the option expires[i] =	$32.14
Coefficient of variation (CV) =	1.518
Time (in years) until the option expires (t) =	1
Variance of the project's expected return = $\ln(CV^2 + 1)/t$ =	119.5%

Notes:

[a]The WACC is 12%. The Year 2 through Year 4 cash flows are discounted back to Year 1.
[b]The standard deviation is calculated as in Chapter 2.
[c]The coefficient of variation is the standard deviation divided by the expected value.
[d]The Year 0 price is the expected NPV from Part 2 of Figure 14A-2.
[e]The Year 1 PVs are from Part 1.
[f]The returns for each scenario are calculated as $(PV_{Year\ 1}/Price_{Year\ 0}) - 1$.
[g]The variance of return is the standard deviation squared.
[h]The expected "price" at the time the option expires is taken from Part 1.
[i]The standard deviation of the expected "price" at the time the option expires is taken from Part 1.

FIGURE 14A-4 Estimating the Value of the Abandonment Option Using a Standard Financial Option (Millions of Dollars)

PART 1. FIND THE VALUE OF A PUT OPTION USING THE BLACK-SCHOLES MODEL

	Real Option				
r_{RF} =	Risk-free interest rate			=	6%
t =	Time until the option expires			=	1
X =	Salvage value if abandon			=	$14.00
P =	Current value of the Project B			=	$18.90[a]
σ^2 =	Variance of Project B's rate of return			=	175.0%[b]
d_1 =	$\{\ln(P/X) + [r_{RF} + (\sigma^2/2)]t\}/(\sigma t^{1/2})$			=	0.934
d_2 =	$d_1 - \sigma(t^{1/2})$			=	−0.39
$N(d_1)$ =					0.82
$N(d_2)$ =					0.35
V of Call =	$P[N(d_1)] - Xe^{-r_{RF}t}[N(d_2)]$			=	$10.99
V of Put =	Call	−	P	+	$e^{-r_{RF}t}$
V of Put =	$10.99	−	$18.90	+	$13.18
V of Put =	$5.28				

PART 2. SENSITIVITY ANALYSIS OF PUT OPTION VALUE TO CHANGES IN VARIANCE

Variance	Option Value
55.0%	$2.29
75.0	2.94
95.0	3.51
115.0	4.02
135.0	4.48
155.0	4.89
175.0	5.28
195.0	5.63
215.0	5.96
235.0	6.27
255.0	6.56

Notes:
[a]The current value of the project is taken from Figure 14A-3.
[b]The variance of the project's rate of return is chosen to be between the variances from Parts 2 and 3 of Figure 14A-3.

Part 1 of Figure 14A-4 shows the calculation of the abandonment option's value. Using the Black-Scholes model for a put option, the resulting value is $5.28 million. Part 2 reports a sensitivity analysis showing the value of the abandonment option for different estimates of variance. For all reasonable estimates, the value of the put is still quite large. The total NPV of the project is the sum of the original project's NPV (which is also equal to the sum of NPVs of Projects A and B) and the value of the option to abandon: Total NPV = −$1.74 + $5.28 = $3.54 million. Given the improvement in NPV caused by the abandonment option, Synapse decided to undertake the project.